RMA/IND - EMCAT - LPD - P1

Energy Management Consultation and Training Project (EMCAT): Loan Portfolio Development Project (LPD)

Pre-Investment Survey
Paper and Pulp Industry

September 1995

Prepared by: **R.A. Young, consultant to**
Resource Management Associates of Madison, Inc.

Prepared for: United States Agency for International Development (USAID)
New Delhi, India
Contract Number: 386-05127-C-00-4100-00

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Preface

Resource Management Associates, Inc. (RMA) is an energy consulting firm located in Madison, Wisconsin, USA. RMA is the prime contractor of the Energy Management, Consultancy, and Training (EMCAT) program. The EMCAT program is funded by the United States Agency for International Development (USAID). Its goal is to promote energy efficiency within India. The following report is a industrial sector energy conservation survey. The focus of the survey was to identify cost effective process modifications which would lead to large scale energy savings. RMA contracted paper process specialist Professor Raymond A. Young, University of Wisconsin, to complete four pulp and paper industry energy conservation surveys in India. The surveys were completed in cooperation with Indian pulp and paper consultants from the firm SPB Projects and Consultancy Ltd. (SPB-PC) of Madras, India. Prior to the surveys, a team of SPB-PC consultants visited the four mills during the period of February 6 - 17, 1995 and prepared a pre-survey report. This was followed by a visit to the same four mills by Professor Young and SPB-PC consultants, R. Lakshminarayanan and S. Ganapathy. This is the combined final report for the consultants from the USA and India.

All results are being forwarded to Project partners and funding agencies. Proprietary information is not being shared among the participating plants.

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Report Glossary

bagasse	sugar cane after the sugar has been removed
ECO	Energy Conservation Opportunity
EMCAT	Energy Management Consultancy and Training
furnish	the specific mixture of raw materials for production of paper, including the different types of pulp and the chemicals from which a particular grade of paper is manufactured
GCV	Gross Calorific Value
grammage	weight basis of paper, defined as weight per unit area of paper, and expressed in grams per square meter. Low grammage is less than 30 grams per square meter
GSM	grams per square meter
kg	kilogram(s) = 2.2 lb
kg/m^3	a density measurement in kilograms per cubic meter
kWh	kilowatt hour(s)
MPM	meters per minute
mTon	metric ton = 2,200 lb = 1,000 kg
pith	the central region of the bagasse; it is not used for paper making
PM	Paper Machine
Rupee	Indian currency equaling 31 Rupees per one US dollar
steam economy	the metric tons of water which is evaporated by one metric ton of steam
street	the process line through which the processing material moves from the raw material stage towards the finished product
tpa	metric tons per annum (year)
tpd	metric tons per day
tph	metric tons per hour
USAID	United States Agency for International Development
VSD	Variable Speed Drive

1. Executive Summary

Four Indian paper plants were visited, and an energy conservation survey of each was made. The survey focus was to identify process modifications which would result in lower unit energy consumption in the manufacture of paper. The following plants are included in this report:

- Seshasayee Paper & Boards Limited, Pallipalayam, Erode, State of Tamil Nadu. (SPB)
- West Coast Paper Mills Limited, Dandeli, State of Karnataka (WCPM)
- Shree Vindhya Paper Mills Limited, Bhusaval, State of Maharashtra (SVPM)
- Orient Paper Mills Limited, Amlai, State of Madhya Pradesh (OPM)

Figure 1.1 shows the location of the identified paper mills.

From the discussions held between the Industrial Development Bank of India (IDBI) and SPB-PC, the following criteria was used to identify four paper mills for participation in the EMCAT study:

- Category-wise representation (large, medium and small mills, based on annual production)
- Region-wise representation
- Age of the mill
- Financial stability
- Willingness to participate in the study

Prior to the site surveys, consultants from SPB-PC visited each plant and prepared a pre-survey study. This study was thorough and presented the major portion of the information required to do each plant survey. The following report is based on information given in the pre-survey study as well as information obtained from discussions during the surveys. Excellent cooperation from each of the facilities facilitated the energy survey success.

Energy cost is 20 - 40% of the total cost to manufacture paper. Energy used in the paper and pulp mills includes steam and electricity. The largest consumer of steam and electricity is the paper making machines, followed by the pulp mills. Steam and power consumption in the paper machines of all the four identified paper mills is higher than expected.

Section 2.6 of this report summarizes the energy conservation opportunities (ECOs) common to those plants surveyed. These ECOs reduce energy consumption in the following ways:

- Mechanically removing process water instead of evaporating it
- Increasing steam utilization in drying
- Recovering waste heat
- Installing more efficient mechanical drives
- Upgrading the process of stock refining
- Increasing combustion efficiency

- Improving thermal insulation
- Installing higher-efficiency pumps
- Increasing lighting efficiency
- Removing water vapor from vacuum pumping systems

Economics and potential energy savings for each plant surveyed is summarized in *Table 1.1*. The cumulative benefit estimate of all projects recommended is an annual savings of 276,360 metric tons (mTons) of steam, 88,200,000 kWh of electricity, 33,000 mTons of coal, and 26 mTons of oil. The total estimated investment is Rs.1,580,100,000 ($50,971,000). This investment would be paid back by energy savings in 4.4 years. Additional savings due to production capacity expansion and product quality improvement have not been included in this summary. A detailed design study is recommended for each of these projects to develop them for financing and implementation.

In the report that follows, energy projects are described on a plant-by plant basis. Where data was not available, or could not be obtained at the plants, estimates were made. For practical reasons, detailed pre-survey information was not included in this report. This detailed data will be valuable during the design and implementation phases of recommendations. The pre-assessment report prepared by SPB-PC is titled *Pre-Investment Study in Paper Industry Under EMCAT Project —Preliminary, March 2, 1995* (SPB Projects and Consultancy Limited, Madras, India).

After each participating plant receives its portion of this report, it will be contacted to determine interest in opportunities identified and obstacles to implementation. Where feasible, the EMCAT Project will assist in removing barriers to the implementation of ECOs.

The proposals highlighted in this report may be taken as general guidance for arriving at the investment potential towards energy conservation in paper industry. Prior to arriving at the precise amount of investment needed for each of the mills, an in-depth technical study and detailed discussions with mill authorities are recommended.

Figure 1.1   Location of Identified Paper Mills

(Cut & Paste)

Table 1.1 Summary of Anticipated Savings - All Plants (Assuming Implementation of all Recommendations)

SESHASAYEE PAPER AND BOARDS LIMITED

ENERGY TYPE	ANNUAL ENERGY SAVED	ANNUAL ENERGY COST SAVINGS	PROJECT INVESTMENT	PAYBACK
Steam	21,500 mTons	Rs 126,250,000 ($ 4,073,000)	Rs 544,300,000 ($17,558,000)	4.3 years
Electricity	40.25 million kWh			
Coal	5,131 mTons			

WEST COAST PAPER MILLS LIMITED

ENERGY TYPE	ANNUAL ENERGY SAVED	ANNUAL ENERGY COST SAVINGS	PROJECT INVESTMENT	PAYBACK
Steam	74,830 mTons	Rs 61,880,000 ($ 1,996,000)	Rs 233,170,000 ($ 7,522,000)	3.8 years
Electricity	16.45 million kWh			
Oil	26 mTons			

SHREE VINDHYA PAPER MILLS LIMITED

ENERGY TYPE	ANNUAL ENERGY SAVED	ANNUAL ENERGY COST SAVINGS	PROJECT INVESTMENT	PAYBACK
Steam	60,780 mTons	Rs 86,110,000 ($2,778,000)	Rs 492,300,000 $15,881,000	5.7 years
Electricity	16.36 million kWh			
Coal	7,840 mTons			

ORIENT PAPER MILLS LIMITED

ENERGY TYPE	ANNUAL ENERGY SAVED	ANNUAL ENERGY COST SAVINGS	PROJECT INVESTMENT	PAYBACK
Steam	119,250 mTons	Rs 82,380,000 ($2,657,000)	Rs 310,330,000 ($10,011,000)	3.8 years
Electricity	15.14 million kWh			
Coal	20,000 mTons			

TOTAL

ENERGY TYPE	ANNUAL ENERGY SAVED	ANNUAL ENERGY COST SAVINGS	PROJECT INVESTMENT	PAYBACK
Steam	276,360 mTons	Rs. 356,620,000 ($11,504,000)	Rs. 1,580,100,000 ($50,971,000)	4.4 years
Electricity	88.20 million kWh			
Coal	33,000 mTons			
Oil	26 mTons			

2. Introduction

2.1 Project Description

The United States Agency for International Development (USAID) is sponsoring a three-year program to promote energy efficiency in India. One component of this program is to promote industrial energy efficiency. To accomplish this, industrial sectors were selected for review to determine what large-scale equipment or process changes could be made to improve energy utilization. The sectors selected are all considered to be energy-intensive industries. This report reports findings for the pulp and paper industry.

2.2 Plant Survey Process

The pulp and paper energy conservation surveys were accomplished by an American and Indian process specialists working together with plant personnel to review the operations and assess consumption per unit of output. The findings at each plant are presented in this report. In addition to the specific evaluation of each plant, the findings will provide the preliminary basis for preparing a Loan Portfolio Design (LPD). Should outside funding be necessary for project implementation, the LPD will provide a lending institution with background to assess the project=s technical merit. Significant, additional detailed engineering design and equipment estimation is required to prepare a final financing package which the lending institution, as well as the plant, could evaluate.

2.3 Pulp and Paper Sector Background

There are about three hundred and forty (340) paper mills in India, widely spread over the entire country, with an aggregate installed capacity of 3.55 million mTons per annum (tpa). These mills registered a total production of around 2.15 million mTons of paper and paper board during the year 1992-93. This amount of production presents a capacity utilization level of around 60 %.

The following list details the quantity of paper/pulp mills and their locations within India:

States of India	No. of Mills
Andhra Pradesh	19
Assam	4
Bihar	8
Chandigarh	1
Gujarat	50
Haryana	16
Himachal Pradesh	15
Jammu and Kashmir	1
Karnataka	14
Kerala	3
Maharashtra	53
Madhya Pradesh	16
Nagaland	1

Orissa	7
Pondicherry	1
Punjab	19
Rajasthan	8
Tamil Nadu	21
Uttar Pradesh	62
West Bengal	21

These paper mills can be further classified according to the annual production range, as presented below:

Annual Production Range (tpa)	Total installed capacity (in thousands of mTons)	Number of mills
Up to 2000	73	48
2000 - 5000	418	122
5000 - 10000	846	106
10000 - 20000	423	26
Above 20000	1787	38

In addition to these paper mills, there are seven (7) newsprint mills having a total installed capacity of 0.33 million tpa.

2.4 Simplified Paper-Making Process

Production of paper has two major process steps: The first is to convert wood or other A lignocellulosic@ material to pulp. The second phase is to form the fibers into the final product.

Pulp is made by converting raw materials such as wood, bamboo, stalks, and reeds into a malleable state either by chemical or mechanical means. Mechanical methods involve straightforward mechanical disintegration in a disk refiner, while chemical methods, although more complicated, give much higher grade pulps. To produce chemical pulps, the raw material is chipped or chopped and then cooked for several hours in a large digester at between 160EC and 170EC (320EF B340EF). Usually, the cooking is done with alkaline chemicals containing sodium and sulfur. The individual fibers are freed during the cooking process. To improve brightness, this fibrous pulp is typically bleached with chlorine compounds. The sodium and sulfur must be recovered from the waste liquid for economic and environmental reasons. This entails a complicated series of steps, including evaporation and burning of the waste organic material, which also creates an opportunity for energy recovery.

For papermaking, the bleached pulp is diluted to a 0.05% concentration in water to disperse the fibers. This slurry is then discharged on a rapidly moving, continuous wire mesh through which the water drains, leaving a wet, fibrous web of cellulosic fibers on the screen. Most of the remaining water is removed by suction, pressing, and passing the web over large, steam-heated steel dryer drums. The paper, now containing only 10% moisture, is compressed to its final thickness by passage through a series of stacked steel cylinders called nips. The solids in the waste water from papermaking are allowed to settle, and the water is recycled or discharged.

2.5 Paper and Pulp Mill Energy Consumption

Paper making is very energy intensive. The cost of energy accounts for 20% to 40 % of the total cost to produce a unit of paper. Paper and pulp mills use electricity and steam for their energy sources. The steam is produced in boilers fueled by coal, pith, lignite, or process waste products. The steam is often generated at high pressure so it can be run through electrical generation turbines prior to being used in the process. Some mills generate enough electricity to meet most of their electrical needs. The process uses steam for its heat to cook and to dry.

Electricity is used for the plant=s motor-driven equipment and for lighting. Motorized equipment includes vacuum pumps, liquid pumps, fans, and conveying equipment.

Table 2.1 details the average amount of energy consumed per metric ton of paper produced. This information indicates the general efficiency of the plants, although an energy-consumption variance is also due to different products being produced at each mill. The best figure to use to determine baseline efficiency for each mill is the AOverall Utilities Consumption@ amount. This figure represents an annual average. In general, the consumption figures for these plants are higher than expected. This indicates strong opportunities for energy conservation.

Table 2.1 Process Power Consumption in the Four Paper Mills Surveyed

Plant/Machine	**Fuel Consumed per mTon of Product**		
	Steam (mTon)	**Electricity (kWh)**	**Water (m^3)**
Seshasayee Paper and Boards Ltd			
Paper Machines			
#1	2.5	572	--
#2	3.5	443	--
#3	2.0	1,103	--
#4	3.0	644	--
Pulp Mill	2.1 - 2.3	210	--
Overall Utilities Consumption	11.4	1,854	260

West Coast Paper Mills Ltd.			
Paper Machines (all)			
Surface Sized Papers	3 - 3.5	--	--
Non-Surface Sized Papers	2 - 2.5	--	--
Paper Machines			
#1	--	750	--
#2	--	500	--
#3	--	800	--
Pulp Mill	2.1 - 2.3	315	--
Overall Utilities Consumption	10.84	1,638	380
Shree Vindhya Paper Mills Ltd.			
Paper Machines			
#1	4.5	800	--
#2	4.0	700	--
#3	4.5	980	--
Pulp Mill	2.6 - 2.7	--	--
Overall Utilities Consumption	6.0	1,256	95
Orient Paper Mills Ltd.			
Paper Machine	2.8 - 3.0	628	--
Pulp Mill	3.1 - 3.3	367	--
Overall Utilities Consumption	15.2	1,635	275 - 300

2.6 Energy Conservation Opportunities In The Pulping Process

All the surveyed mills have adopted the kraft pulping process. This process uses sodium hydroxide and sodium sulphide as cooking chemicals. Almost all the paper mills in India have adopted the same pulping process, in preference to soda pulping. This is because of the better pulp yield and better pulp strength properties realized by the kraft process. The plants surveyed lacked the process steps found in newer plants, such as high-consistency bleaching, extended delignification, and pressure washing.

2.7 Energy Conservation Opportunities in the Paper Machine Sections

Several ECOs were common to all the plants surveyed. The following is a summary of these opportunities.

Press

All the identified mills have single-nip/bi-nip presses. A more advanced method is known as the tri-nip or extended-nip press. The more advanced machines are superior to the older machines because they get greater dryness off the press. Greater dryness reduces the steam consumption used for drying in the paper machine.

Dryer

Of the four plants, Orient Paper Mills Limited is the only one which has adopted the proven A cascade@ system for steam use and condensate removal in the dryer section. The cascade system is superior because it reduces the amount of steam consumed in the dryer section.

Heat Recovery System

Dryer exhaust heat recovery has not been implemented by any of the four mills surveyed. Heat recovery would provide additional steam savings. Most new paper and pulp facilities include dryer heat recovery as part of their design.

Machine Drives

Seshasayee Paper and Boards Limited and Orient Paper Mills Limited have steam turbine drives for their paper machinery. The present trend in the paper industry is to standardize on direct current (DC) thyristor controls or AC variable speed drives (VSD). This reduces the overall steam consumption of the paper mills and saves energy. Energy is saved because the overall energy efficiency of electrical motors is better than that of steam drives for this application.

Stock Preparation BRefiners

All the mills, except Orient Paper Mills Limited, have installed double-disc refiners, for refining the stock. This technology is well-proven. Orient Paper Mills Limited has installed a Jordan refiner, which consumes more electrical power than the double-disc refiners.

2.8 Energy Conservation Opportunities in the Chemical Recovery Process

Evaporator

All the mills have installed rising-film evaporators. The modern trend is to implement falling-film evaporators which offer higher steam economy.

Power Boiler

The mills have steam boilers which use either a pulsating technology, or a spreader stoker traveling grate system to fuel the boilers. To provide better combustion of the fuel, some of the new mills in India adopt the latest technology of fluidized-bed combustion (FBC) for efficient operation of the boilers. The mills should consider FBC when installing a new boiler.

2.9 Non-Process Energy Conservation Opportunities Common to All Mills

Thermal Insulation

In each of the four mills, thermal insulation is missing or damaged in some areas. These areas include steam piping, tanks, and vessels. Ample scope exists to reduce steam loss by improving insulation where not currently optimum.

Pumps

While reviewing the operations in all the four mills, the survey team noted that the mills employ a considerable number of old generation pumps, especially in the areas of water intake and circulation. These pumps have efficiencies which are low compared to current standards. A detailed study of the plant can provide a complete list of inefficient pumps. Given the amount of electricity that pumping consumes, a pump replacement program is recommended.

Mill Lighting

All of the mills surveyed use magnetic ballast fluorescent and mercury vapor lamps. By upgrading fluorescent ballasts to reputable electronic ballasts, and mercury vapor fixtures to metal halide or high-pressure sodium fixtures, 30 to 40 percent of the lighting electrical load will be reduced.

Vacuum Pumps

Generally, old paper mills do not employ water separators at the inlet of vacuum pumps. Because the provision of water separators will bring down the electric power of the vacuum pumps, implementation of water separators at the inlet of plant vacuum pumps is identified as an ECO.

3. Seshasayee Paper and Boards Ltd., Pallipalayam, Erode

3.1 Executive Summary

The Seshasayee Paper Mill is located at Pallipalayam, near Erode, in the Salem District of Tamil Nadu. The plant was commissioned in 1960, to produce 19,800 metric tons (mTons) of writing and printing paper per year. The mill expanded in the years 1968 and 1977 to an annual production of 56,100 mTons per year. The plant's production capabilities, after expansion, include writing and printing paper, paper board, and low-grammage posters. Production presently utilizes wood, bagasse, and waste paper as raw materials. The mill has an ample supply of raw materials and energy. Currently the facility has 1,946 employees. During 1993-94, the mill registered sales of Rs. 1035.3 million ($33.4 million) and a gross profit of Rs. 127.7 million ($4.1 million).

The plant's primary energy sources are steam and electricity. For each metric ton of product made, the plant uses an average of 11.4 mTons of steam and 1,854 kWh of electricity. The largest share of steam and electricity is used by the paper-making machinery. The objective of this report is to present recommendations to reduce energy consumption per unit of output.

Together, the survey team and plant staff identified the following Energy Conservation Opportunities (ECOs):

1. Replace existing pneumatic handling system from chipper to digester by a suitable belt conveyor system.

2. Replace existing digester preheaters

3. Replace existing centrifugal screens for both bagasse and wood streets with high-consistency pressure screens

4. Replace existing high-pressure-drop, low-efficiency centricleaners for both wood and bagasse streets with low-pressure-drop, high-efficiency, high- consistency centricleaners

5. Implement additional pith drying prior to burning

6. Install additional body and preheater for the new evaporator street

7. Install electrostatic precipitator for the chemical recovery boiler #1

8. Install a closed hood with heat recovery system for PM #1, PM #2 and rectify the hood system for PM #3

9. Install water separators in the vacuum pumps as applicable to the duty requirement

10. Replace the steam drives of PM #2 with common DC drive

11. Install boiler/turbo alternator

12. Replace electrical distribution transformers

13. Retrofit pump drives with variable speed drives (VSD) for PM #3

14. Repair and replace thermal insulation

15. Replace old generation pumps with efficient pumps

16 Lighting source upgrades

17. Improve utilization of backwater by implementing a closed system

If all of these measures were implemented, the impact on the plant is estimated to be an annual savings of 21,500 mTons of steam, 40.25 million kWh of electricity, and 5,131 mTons of coal. The annual energy savings value of these measures is estimated at Rs. 126,250,000 ($4,073,000).. The investment needed to realize these savings is approximately Rs. 544,300,000 ($17,558,000), which would provide a payback period of 4.3 years. These estimates are provided to determine savings potential. Detailed implementation designs will provide estimates with greater precision.

3.2 Process Survey Background

The mill utilizes eucalyptus, bagasse, and small quantities of bamboo as the major raw materials for making several varieties of paper. Some amount of waste paper is also used in the furnish. Annually, the mill consumes around 65,000 mTons of eucalyptus, 60,000 mTons of bagasse, 8,000 to 9,000 mTons of bamboo, and 2,000 mTons of waste paper. The raw materials are obtained from forest areas, as well as from the adjoining Ponni Sugars and Chemicals Limited plant. The mill has not faced any major hardship in meeting its raw material requirements. The mill utilizes eucalyptus and bagasse as the primary raw materials for making the pulp used for different varieties of paper. Eucalyptus wood is chipped, cooked in vertical stationary batch digesters, washed, screened, cleaned, and bleached in a dedicated system using a C-E-H-H bleaching sequence.

Bagasse is received, in depithed form, from the adjoining Ponni Sugars and Chemicals Limited plant. The bagasse is slushed and, after washing, it is cooked in a horizontal, continuous Pandia digester. The pulp is then washed, screened, cleaned, and bleached in a dedicated system using a C-E-H bleaching sequence.

The two largest consumers of electricity in paper making are the paper machines and the pulping process. For this reason, many of the identified ECOs involve these process areas. As *Table 3.1* shows, the total steam consumed is 11.4 mTons per mTon of paper produced.

Table 3.1 Process Power Consumption at Seshasayee Paper

Plant/Machine	Fuel Consumed per mTon of Product		
	Steam (mTon)	**Electricity (kWh)**	**Water (m^3)**
Seshasayee Paper and Boards Ltd			
Paper Machines			
#1	2.5	572	--
#2	3.5	443	--
#3	2.0	1,103	--
#4	3.0	644	--
Pulp Mill	2.1 - 2.3	210	--
Overall Utilities Consumption	11.4	1,854	260

Again referring to *Table 3.1*, total electricity consumed is about 1,854 kWh per mTon of paper produced. The steam and power consumption at this mill is higher than optimum. Together, the plant staff and the survey team identified a list of energy-saving recommendations. Sections 3.3 and 3.4 describe these recommendations.

3.3 Estimated Savings from Implementation of ECOs

Pulping Section

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #1 Replace pneumatic handling system	10.5	0.95	--	--	2.7
ECO #2 Replace digester preheaters	5.0		--	--	0.57
ECO # 3 Replace existing centrifugal screens with high-consistency pressure screens	8.0	0.45	--	--	1.28
ECO #4 Replace existing high-pressure-drop centricleaners with low-pressure-drop centricleaners	4.0	0.25	--	--	0.71
ECO #5 Implement additional pith drying	4.0	--	213 (coal)	--	1.6

Chemical Recovery Section

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #6 Install additional body for new evaporator street	5.5	--	11,550	--	2.9
ECO #7 Install electrostatic precipitator for chemical recovery boiler #1	17	1.25	--	--	3.55

Paper Machine

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #8 Install closed hood hood for PM #1, PM #2, and PM #4	16.00	0.18	9,950	--	3.05
ECO #9 Install water separators for vacuum pumps	5.00	--	--	0.23	0.23
ECO # 10 Replace steam drives for PM #2 with DC electric drive	5.00	0.57	--	--	1.63

Utilities

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO # 11 Install of two (2) 40 tph, 63 kg/cm^2, 465 °C power boilers					
and					
Install one 5-MW, double-extraction condensing turbo alternator and one 10.5 MW, single-extraction condensing turbo alternator set with all auxiliaries	450	36.00	4,918 (coal)	--	106.29

Electrical

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO # 12 Replace distribution transformers	11	0.4	--	--	1.14

ECO #13 Retrofit pumps with VSDs for PM #3	3.3	0.2	--	--	0.6

General

Description Savings	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual (Million Rupees)
ECO #14 Repair and replace thermal insulation	2.75	--	3770	--	0.96
ECO # 15 Replace old generation pumps with efficient pumps	7.15	1.4	--	--	3.99
ECO #16 Lighting source upgrades	2.2	0.25	--	--	0.71
ECO #17 Improve utilization of backwater by implementing a closed system	3.0	0.05	--	0.76	0.90
TOTALS	544.30	40.25	21,500 + 5,131 mTon of coal	0.23	126.25

3.4 Recommendations

ECO #1 Replace existing pneumatic handling system from chipper to digester by a suitable belt conveyor system

The mill has installed one Sumner disc chipper and two HH300 disc chippers for meeting the chips requirement of the mill. Presently, the wood chips are transported from the chipper house to the chips silo, and from the chips silo to stationary digesters, through a pneumatic conveying system. This system involves approximately 275 kW of electric power. Pneumatic handling requires more energy than belt conveying. The survey team recommends converting the existing system to a suitable belt-conveyor system.

ECO #2 Replace existing digester preheaters

The mill uses a kraft pulping process. To support this process, the mill has installed vertical, stationary, batch-type digesters with an indirect, steam-heating arrangement. Presently, the mill is bypassing the preheaters and injecting steam directly into the digesters. This process of direct injection lacks precise control of steam, does not return any condensate to the boiler, and produces steam which condenses and dilutes the cooking liquor / black liquor.

The survey team recommends putting the preheaters into operation. Operation of the preheaters will save energy by more strictly controlling the amount of steam used in the process, returning condensate for heat recovery and reuse in the boilers, and eliminating dilution of the weak black liquor which is pumped to the chemical recovery section.

ECO #3 Replace existing centrifugal screens for both bagasse and wood streets with high-consistency pressure screens

The installed power of the pulp section is approximately 4,200 kW. This includes both the bagasse and wood pulp mills.

Both the wood and bagasse pulp mills use centrifugal screens for screening unbleached pulp. The present design of the centrifugal screens necessitates their operation at a slurry consistency of about 0.5 to 0.6%. This is a relatively low concentration of pulp in the water. Because of the low pulp concentration, the amount of pumping energy required is greater than expected.

The survey team recommends replacing existing screens with high-consistency pressure screens to reduce the amount of pumping energy.

ECO #4 Replace existing high-pressure-drop, low-efficiency centricleaners

To clean unbleached pulp, both the wood and bagasse pulp mills have high-pressure-drop centricleaners. The design of these centricleaners necessitates operation at a relatively low slurry consistency of pulp. This leads to a larger amount of electric power in the process for pumping the unbleached pulp.

The survey team recommends replacing existing high-pressure-drop, low-efficiency centricleaners of both the wood and bagasse streets with low-pressure-drop, high-efficiency, high-consistency centricleaners. They will perform the same function while reducing pumping energy.

ECO #5 Implement additional pith drying prior to burning

Pith is a waste product of the paper-making process. Since it has a high heating value, it is burned in boilers as a fuel source. Currently, the pith has a high moisture content during burning. This is due to limited sun drying. At a high moisture level, the pith's available heating value is severely diminished. The survey team recommends complete sun-drying of the pith prior to burning it. By doing this, the additional heat value available from the pith will eliminate a portion of the coal currently burned in the boilers.

ECO #6 Install an additional body and preheater for the new evaporator street

The mill has two streets of evaporators, one new and one older. The older street is not used, but is kept as a back-up system.

The present steam economy of the new street is 5 mTons of evaporation / mTon of steam. The survey team recommends that an additional evaporator body ,with a preheater, be installed in the new street. This will reduce the amount of steam needed per unit of material that is processed in the evaporator.

ECO #7 Install an electrostatic precipitator for the chemical recovery boiler #1

The mill has two chemical-recovery boilers. Chemical-recovery boiler #1 uses a venturi scrubbing system to recover valuable chemicals from the flue gas. This method creates a significant pressure drop across the exhaust stack. The large pressure drop requires more induced-draft-fan energy.

The survey team recommends replacement of the existing scrubbing system with an electrostatic precipitator. This will reduce the pressure drop across the scrubbing system which, in turn, will reduce the energy required for the induced-draft fan.

ECO #8 Install a closed hood with heat recovery system for Paper Machine #1, #2, and #4. Also rectify hood system for Paper Machine #3

Presently, the paper machines (except #3) have open hoods which allow heat to escape. The survey team recommends installing hoods with heat recovery units to recover heat which is presently lost.

ECO #9 Install water separators in the vacuum pumps

The vacuum pumps are used to remove moisture during the paper-making process. When this moisture is mixed with the air which goes through the vacuum pumps, it causes additional expenditures of energy. By installing water separators prior to the vacuum pumps, this energy waste will be eliminated.

ECO #10 Replace the steam drives used on Paper Machine #2 with a common DC drive

Presently, the paper machines have drive systems which use steam to make them turn. For this application, the overall efficiency of using steam drives is less than using electrically powered direct current (DC) drives. To reduce the amount of energy used in the paper machines, the survey team recommends replacing the steam drives with electric DC drives.

ECO #11 Install boiler and turbo alternator (generator)

The mill has a boiler house which cogenerates steam and electricity. In the present balance, three multi-fuel boilers, along with chemical recovery boilers, meet the entire steam load and about one-half of the mill's 12-MW electrical needs. The remaining electrical needs are purchased from the State Electricity Grid.

Both the efficiency of steam generation and the turbine efficiency can be improved. By improving these efficiencies, the amount of fuel consumed will be reduced.

Efficiency in steam production can be improved by taking the following steps:

- Tuning the boilers for improved thermal efficiency
- Reducing the excess air levels by attending to leaking grate seals and settings
- Replacing the existing fuel feeding system

Efficiency in electricity production can be improved by replacing the existing turbine rotor and governing system of the 5-MW turbo alternator set. This will upgrade the existing efficiency from 47.5% to 65%. This will increase the amount of power generated on site, thus reducing the amount of power purchased from the State electricity grid.

Mill authorities plan to upgrade the boiler house and power plant. The proposed plans will take into consideration the improvements recommended above. As part of the upgrade, the plant is including the installation of two fluidized-bed power boilers and two turbo alternator sets with a total power generation capacity of 15.5 MW.

ECO #12 Replace electrical distribution transformers

Presently the mill has sixteen 750-kVa transformers which take 3,300-volt power and step it down to 433 volts. A review of the transformer loading indicates that in addition to aging losses, the transformers are not optimally loaded. The result is higher electrical distribution losses.

The survey team recommends installing five 2,000-kVa distribution transformers to reduce distribution losses.

ECO #13 Install VSDs for Paper Machine #3 pumps

Presently the Paper Machine #3 pumps are running at full speed, although the volume is not necessary. Because of this, PM #3 consumes a large amount of power when compared to the other three paper machines. The survey team recommends installing VSDs on these pumps to match the specific demand. This will reduce the electrical consumption of PM #3 pump motors.

ECO #14 Thermal Insulation

The thermal insulation in a portion of the plant's steam piping, tanks, and vessels is damaged or missing. By simple replacement of this insulation, steam loss will be reduced.

ECO #15 Replace old generation pumps by energy-efficient pumps

The survey team observed that the mill employs a considerable amount of old generation pumps. This was seen particularly in the areas of water intake and circulation. These pumps have efficiencies which are low compared to current standards. A detailed study of the plant can provide a complete list of low-efficiency pumps. Given the amount of electricity that pumping consumes, a pump replacement program is recommended.

ECO #16 Lighting improvements

Existing exterior lighting is mercury vapor technology. Replacing the mercury vapor lamps and ballasts with high-pressure sodium or metal-halide technology will significantly reduce the electricity cost of exterior lighting. Metal halide has a white light and is twice as efficient as mercury vapor. High-pressure sodium lamps have a yellow-gold light and are about three times as efficient as mercury vapor lights.

ECO #17 Improve backwater utilization

Presently the water used in the paper-making machines is discharged. To reduce pumping electricity, the survey team recommends closing the water supply loop by recycling this process water, reusing it in the paper-making machines.

3.5 General Plant Data

Name of the Paper Mill	SESHASAYEE PAPER & BOARDS Ltd.
Address of Registered Office	Pallipalayam, Cauvery R.S. P.O. Erode 638 007, Tamil Nadu
Location of the Factory	Same as above
Address of the Factory	Same as above
Phone Telex Telefax	(91) (4289) 40221/228 (81) (856) 220 SPB IN (91) (4289) 40229
Date of Incorporation	22-06-1960
Name of the Mill Manager	Mr. K. S. Kasi Viswanathan
Name of the Proposed Coordinator for Energy Conservation Study	Mr. S. Ravi Raghavan
No. of Employees:	
Direct	1,946
Indirect	--

4. West Coast Paper Mills Ltd., Dandeli

4.1 Executive Summary

The West Coast Paper Mill (WCPM) is located at Village Bangur Nagar, in Uttara Kannada District of Karnataka. It was incorporated in 1955. Presently, the mill is manufacturing writing and printing paper, at an average of around 145 metric tons per day (tpd). It also produces packing and board varieties at an average of 65 tpd. In addition to wood, the mill utilizes eucalyptus and bamboo as the major raw material for making pulp for different varieties of paper. Recently, the mill started utilizing small quantities of imported pulp and waste paper as raw material. The present number of mill employees is 3200. During 1993-94, the mill registered sales of Rs. 174.7 million ($5,635,000) and a profit of Rs. 25.25 million ($815,000) after tax.

The plant's primary energy sources are steam and electricity. For each mTon of product made, the plant uses 10.84 mTons of steam, and 1,638 kWh of electricity. The largest share of steam and electricity is used in the paper machines. The objective of this report is to present recommendations to reduce energy consumption per unit of output.

Together, the survey team and plant staff identified the following Energy Conservation Opportunities (ECOs):

1. Convert from pneumatic to belt conveying for chips handling system
2. Replace existing centrifugal screens with high-consistency pressure screens
3. Replace high-pressure-drop centricleaners with low-pressure-drop centricleaners
4. Replace existing evaporators with falling-film evaporators
5. Improve combustion efficiency and reduce radiation loss in lime kiln
6. Install closed hoods with heat recovery units on paper machines
7. Replace rotor and governing system on five-megawatt turbo alternator set
8. Install rewinder with a thyristor drive on Paper Machine # 2
9. Receive grid power at a higher voltage
10. Repair or replace thermal insulation
11. Replace old generation pumps with improved efficiency pumps

12. Upgrade lighting efficiency

13. Improve backwater utilization by creating a closed system

If all of the above measures are implemented, the impact on the plant is estimated to be an annual savings of 74,830 mTons of steam, 16.45 million kWh of electricity, and 26 mTons of oil. The annual energy savings value is estimated at Rs 61,880,000 ($1,996,000). Investment needed to realize these savings is Rs. 233,170,000 ($7,522,000) which would provide a payback of 3.8 years. Sections 4.3 and 4.4 summarize the ECOs. Detailed implementation designs of the above measures will provide estimates with greater precision.

4.2 Process Survey Background

The mill utilizes eucalyptus and bamboo as the major raw material for making pulp for different varieties of paper. Recently, the mill has started utilizing small quantities of imported pulp and waste paper as raw materials. Annually, the mill consumes around 200,000 mTons of eucalyptus, 7,000 mTons of bamboo, and 1,400 mTons of imported pulp and waste paper. The raw material for the mill is obtained mostly from forest areas. The mill has not faced any major hardship in meeting its raw material requirements.

The two largest consumers of energy in paper making are the paper machines and the pulping process. For this reason, many of the identified ECOs involve these process areas. As *Table 4.1* shows, the total steam consumed is 10.84 mTons of steam per mTon of paper produced. Again referring to *Table 4.1*, total electricity consumed is about 1,683 kWh per mTon of paper produced.

Table 4.1 Process Power Consumption at West Coast Paper

Plant/Machine	**Fuel Consumed per mTon of Product**		
	Steam (mTon)	**Electricity (kWh)**	**Water (m^3)**
West Coast Paper Mills Ltd.			
Paper Machines (all)			
Surface Sized Papers	3 - 3.5	--	--
Non-Surface Sized Papers	2 - 2.5	--	--
Paper Machines			
#1	--	750	--
#2	--	500	--
#3	--	800	--
Pulp Mill	2.1 - 2.3	315	--
Overall Utilities Consumption	10.84	1,638	380

Steam and power consumption at this mill, as shown above, is higher than optimum. Together, the plant staff and the local and U.S. EMCAT consultants have identified energy-saving recommendations. The following sections of this report present brief descriptions of the energy-saving opportunities.

4.3 Estimated Savings from Implementation of ECOs

Pulping Section

Description	Estimated Investment	......Anticipated Savings/Year......			Anticipated Annual Savings
		Elect. Energy	Steam	Water	
	(Million Rupees)	(Million KWh)	(tpa)	(Million m^3)	(Million Rupees)
ECO#1 Convert pneumatic to a Belt conveying for chips handling system	7.50	1.07	--	--	2.35
ECO#2 Replace existing centrifugal screens with high consistency pressure screens	7.00	0.90	--	--	1.90
ECO#3 Replace existing high-pressure drop centricleaners with low-pressure drop centricleaners	3.5	0.40	--	--	0.88

Chemical Recovery Section

Description	Estimated Investment	......Anticipated Savings/Year......			Anticipated Annual Savings
		Elect. Energy	Steam	Water	
	(Million Rupees)	(Million KWh)	(tpa)	(Million m^3)	(Million Rupees)
ECO #4 Replace existing evaporators with falling-film evaporators	120.00	--	57,300	--	18.90
ECO #5 Improve combustion efficiency and reduce radiation loss in lime kiln	0.70	--	26 (Fuel oil)	--	0.16

Paper Machine

Description	Estimated Investment	......Anticipated Savings/Year......			Anticipated Annual Savings
		Elect. Energy	Steam	Water	
	(Million Rupees)	(Million KWh)	(tpa)	(Million m^3)	(Million Rupees)
ECO #6 Install closed hoods, with heat recovery units, on paper	25.00	0.24	13,760	--	5.10

machines

Utilities

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #7 Replace rotor and governing system on 5-MW turbo alternator set	40.07*	10.30	--	--	22.50

* Includes cost of power drawn from the grid during the shut-down period of 60 days.

Electrical

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #8 Install rewinder with a thyristor drive on paper machine #2	1.10	0.09	--	--	0.20
ECO #9 Receive grid power at higher voltage	16.50	2.70	--	--	5.90

General

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO # 10 Repair and replace thermal insulation	3.85	--	3,770	--	1.24
ECO #11 Replace old generation pumps by energy-efficient pumps	2.75	0.42	--	--	0.92
ECO #12 Upgrade lighting efficiency	2.20	0.26	--	--	0.58
ECO #13 Improve backwater utilization by creating a closed system	3.0	0.07	--	1.10	1.25

TOTALS	233.17	16.45	74,830 + 26 (fuel oil)	1.10	61.88

4.4 Recommendations

ECO #1 Convert pneumatic conveying system to belt conveying system

Presently, wood chips are transported from the chips silo to stationary digesters by means of a pneumatic conveying system. This system involves 260 kW of electric power. The energy required to convey material using mechanical belt handling is less than when using pneumatic (air) handling. By redesigning the conveying system to utilize mechanical conveying, electrical energy consumption will be reduced.

ECO #2 Replace existing centrifugal screens with high-consistency pressure screens

The pulping section has centrifugal screens to screen unbleached pulp. The design of the centrifugal screens necessitates operation at a consistency of about 0.5% to 0.6%. This is a lower consistency of pulp than is expected. By implementing a higher-consistency pressure screen, energy will be saved through pumping less volume to achieve the same result.

ECO #3 Replacement of high-pressure-drop centricleaners with low-pressure-drop centricleaners

The pulping section uses centricleaners for cleaning unbleached pulp. The existing units create a large pressure drop. In addition, the design of these centricleaners requires operation at a pulp consistency of 0.5% to 0.6%. This is a lower consistency of pulp than is expected. A larger amount of power for pumping is consumed in the centricleaning section. The centricleaning system can be made more energy-efficient by redesigning the centricleaners to allow a higher consistency of pulp, while reducing the pumping pressure required. This will reduce the amount of electricity used for pumping.

ECO #4 Replace existing evaporators with falling-film evaporators

The mill currently has three streets of short-tube vertical evaporators. Each street has a water evaporation capacity of 25 tph. With the existing evaporators, an overall steam economy of 3.8 to 3.9 is achieved. By installing new streets of falling-film evaporators, a steam economy of about 5.5 will be achieved. This increase in economy will provide a large steam savings.

ECO #5 Improve combustion efficiency and reduce radiation loss in lime kiln

The survey team observed that the furnace is overloaded. This leads to improper combustion of fuel oil. Regulation of the lime kiln to prevent overloading will reduce consumption of oil.

Also noted was a high degree of radiation loss in the furnace. It is likely that additional heat is wasted as a result of insufficient kiln lining. The survey team recommends an upgrade of the refractory lining inside the kiln to bring down exterior heat losses.

ECO #6 Install closed hoods with heat recovery on paper machines

The mill has installed three paper machines. The machines have finished-product capacities of 55 tpd, 65 tpd, and 90 tpd. All three machines have open hoods and employ a cascade system for steam and condensate. By installing closed hoods with heat recovery units on each paper machine, heat which is now lost will be recovered and put back into the process. This will reduce steam consumption.

ECO #7 Replace rotor and governing system for five-megawatt turbo alternator set

The power plant of the mill comprises three turbo alternator sets, each capable of generating five megawatts of power. Generally, the mill runs sets #1 and #3 only. The combined average power generation of both sets is 6,700 kW, while the total mill electrical requirement is 13,000 kW. The balance of the electrical requirement is drawn from the State electricity grid.

Based on process steam extraction amounts, it is projected that the electricity generated should be 8.3 MW. This lower electricity production is attributed to reduced efficiency in the 5-MW A TRIVENI@ turbo alternator. By replacing the rotor / blading and governing system of the 5-MW A TRIVENI@ turbo alternator set, electricity generated will be increased. This increase in on-site electricity production will reduce the amount of electricity purchased from the State electricity grid.

ECO #8 Install a rewinder with a thyristor drive on Paper Machine #2

The Paper Machine #2 rewinder is presently driven with a DC drive which is electrically fed by a motor-generator set. This arrangement results in appreciable energy loss through electrical conversion and transmission. By retrofitting the Paper Machine #2 rewinder with a thyristor drive, the electrical efficiency will be improved. This will reduce power consumption of this paper machine.

ECO #9 Receive grid power at a higher voltage

The mill's power requirement is met both by the State electricity grid, and the mill's cogeneration. Presently the mill is supplied by the State electricity grid at 11,000 volts. It is recommended to investigate the possibilities of having power distributed to the mill at a higher voltage. This would reduce the distribution line losses that are presently experienced.

ECO#10 Repair and replace thermal insulation

The thermal insulation in a portion of the plant's steam piping, tanks, and vessels is damaged or missing. By simple replacement of this insulation, steam loss will be reduced.

ECO #11 Replace old generation pumps by energy-efficient pumps

The survey team observed that the mill employs a considerable amount of old generation pumps. This was seen particularly in the areas of water intake and circulation. These pumps have efficiencies which are low compared to current standards. A detailed study of the plant can provide a complete list of low-efficiency pumps. Given the large amount of electricity that pumping consumes, a pump replacement program is recommended.

ECO #12 Lighting improvements

Existing exterior lighting is mercury vapor technology. Replacing the mercury vapor lamps and ballasts with high-pressure sodium or metal-halide technology will significantly reduce the electricity cost of exterior lighting. Metal halide has a white light and is twice as efficient as mercury vapor. High-pressure sodium lamps have a yellow-gold light and are about three times as efficient as mercury vapor lights.

ECO #13 Better utilization of backwater by closing the system

Presently, the water used in the paper-making machines is discharged. To reduce pumping electricity, the survey team recommends closing the water supply loop by recycling this process water, reusing it in the paper-making machines.

4.5 General Plant Data

Name of the Paper Mill	WEST COAST PAPER
Address of Registered Office	P.O. Box #5, Bangur Nagar Dandeli 581 325 Dist. Uttara Kannada Karnataka State
Location of the Factory	Bangur Nagar, Dandeli PO
Address of the Factory	Same as for Registered Office
Phone	(91) 89391-89395 (5 lines)
Telefax	(91) 08383-225
Date of Incorporation	May 1955
Name of the Mill Manager	Mr. K. L. Chandak (Vice President - Administration)
Name of the Proposed Coordinator for Energy Conservation Study	Mr. G.D. Maheshwari (Vice President - Technical)
No. of Employees:	
Direct	3,200
Indirect	7,000

5. Shree Vindhya Paper Mills Limited, Bhusaval

5.1 Executive Summary

The Shree Vindhya Paper Mill is located at Somani Nagar, Village Duskheda near Bhusaval in Jalgaon District of Maharashtra. It was incorporated in 1964. Presently, the mill is manufacturing writing and printing paper at an average rate of 52 tpd, ledger and parchment paper at an average rate of 16 tpd, and M.G. poster varieties at an average rate of around 32 tpd. The mill utilizes a furnish mix of 75% bagasse pulp and 25% waste paper/purchased pulp. The present number of direct mill employees is 776. The mill has registered an increasing trend in sales and cash profit during 1993-94, compared to the numbers from 1992-93. During 1993-94, the mill registered sales of Rs. 400.4 million ($12,916,000) and cash profit of Rs. 43.6 million ($1,406,000).

Energy sources used on site are primarily steam and electricity. Both steam and electricity are used mainly in the pulp mill and paper machines. For each mTon of paper produced, the plant utilizes 6 mTons of steam and 1,256 kWh of electricity. The objective of this report is to present recommendations to reduce energy consumption per unit of output.

Together, the survey team and plant personnel identified the following energy conservation opportunities (ECOs):

1. Replace rotary digesters with continuous digesters
2. Upgrade instrumentation and controls
3. Replace press sections on PM #1 and PM #2
4. Install closed hoods for PM #1 and PM #2
5. Install boiler and matching double-extraction TA set
6. Install capacitors
7. Repair or replace thermal insulation
8. Replace old generation pumps with improved efficiency pumps
9. Upgrade lighting
10. Improve backwater utilization by creating a closed system

If all of the above measures are implemented, the impact on the plant is estimated to be an annual savings of 60,780 mTons of steam, 16.36 million kWh of electricity, and 7,840 mTons of coal. The combined annual savings value of the recommendations is Rs. 86,110,000 ($2,778,000). The estimated investment needed to realize these savings is Rs. 492,300,000 ($15,881,000) , which would provide a payback of 5.7 years. Sections 5.3 and 5.4 describe each of the ECOs. These estimates are provided to determine savings potential. Detailed implementation designs will provide more precise estimates.

5.2 Process Survey Background

The mill utilizes bagasse as the major raw material for making several varieties of paper. Small quantities of wheat straw, waste paper, and purchased pulp are also used in the furnish. Annually, the mill consumes around 64,000 mTons of bagasse, 1,000 mTons of wheat straw, and 6,000 mTons of waste paper and purchased pulp. The mill has not faced any major hardship in meeting its raw material requirements.

Bagasse is received as surplus from the nearby sugar mills and depithed in the paper mill. The depithed bagasse is cooked in rotary spherical digesters using the kraft process. The pulp is then washed, screened, cleaned and bleached using C-E-H bleaching sequence.

Energy used in the pulp and paper-making processes is summarized below. Steam and electricity are the primary sources of energy consumed.

Table 5.1 Process Power Consumption at Shree Vindhya Paper

Plant/Machine	Fuel Consumed per mTon of Product		
	Steam (mTon)	**Electricity (kWh)**	**Water (m^3)**
Shree Vindhya Paper Mills Ltd.			
Paper Machines			
#1	4.5	800	--
#2	4.0	700	--
#3	4.5	980	--
Pulp Mill	2.6 - 2.7	--	--
Overall Utilities Consumption	6.0	1,256	95

Together, the plant staff and the survey team identified a list of ECOs that can reduce the energy consumed per unit of output. Sections 5.4 and 5.4 of this report describe these ECOs.

5.3 Estimated Savings from Implementation of ECOs

Pulping Section

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #1 Replace rotary digesters with continuous digester	100.00	--	5,300	--	22.20
ECO #2 Instrumentation and controls	25.00	--	8,600	--	7.70

Paper Machine

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #3 Replacement of press sections for PM #1 and PM #2	40.00	--	39,600	--	9.90
ECO #4 Installation of closed hoods for PM #1 and PM #2	10.50	0.09	5,280	--	1.55

Utilities

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #5 Installation of one 65 tph 42 kg/cm^2, 420 ^oC boiler and 1 x 5-MW matching double-extraction & condensing TA set along with all auxiliaries	312.00	15.84	7,840 (coal)	--	43.0

Electrical

Description	Estimated Investment	......Anticipated Savings/Year...... Elect. Energy	Steam	Water	Anticipated Annual Savings
	(Million Rupees)	(Million KWh)	(tpa)	(Million m^3)	(Million Rupees)
ECO #6 Installation of capacitors	0.33	0.26	--	--	0.65

General

Description	Estimated Investment	......Anticipated Savings/Year...... Elect. Energy	Steam	Water	Anticipated Annual Savings
	(Million Rupees)	(Million KWh)	(tpa)	(Million m^3)	(Million Rupees)
ECO #7 Repair and replacement of thermal insulation	1.65	--	2,000	--	0.50
ECO #8 Replacement of old generation pumps by efficient pumps	0.22	0.03	--	--	0.08
ECO #9 Lighting	1.10	0.13	--	--	0.33
ECO #10 Better utilization of back water by closing the system	1.50	0.01	--	0.18	0.20
TOTAL OF ALL ECOS	492.3	16.36	60,780 + 7,840 (coal)	0.18	86.11

5.4 Recommendations

ECO #1 Replace rotary digesters with continuous digesters

The mill employs a kraft pulping process and has installed five rotary, spherical-batch, bagasse -pulping digesters. In these digesters, both steam and electricity are utilized. Steam is utilized by using direct injection.

Continuous digesters have a greater steam-utilization efficiency than rotary digesters. Replacing the existing digesters with continuous digesters will consume less steam, use fewer chemicals, and improve pulp quality and yield.

ECO #2 Install instrumentation and controls

Presently, the pulping section has almost no instrumentation to guide the manual control of steam, chemicals, or water. If monitoring instrumentation is implemented, there will be a reduction in the consumption of steam, chemicals, and water because of the ability to precisely control the input of these resources.

ECO #3 Replace press sections for Paper Machine #1 and Paper Machine #2

The paper machines use 2,550 kW of connected motors to pump the fiber slurry, move the wire web, draw off water, and compress the paper. After these steps, steam is used for drying the remaining moisture in the paper. PM #1 and PM #2 employ, respectively, a three-stage and four-stage cascade system for steam and condensate recovery.

The press sections of PM #1 and PM #2 are not removing the maximum amount of water from the fibrous web, causing a lower off-press web dryness. This condition leads to high steam consumption in subsequent drive stages. By upgrading the press sections, the paper will have lower off-web dryness which will reduce steam consumption in the final stages of the process.

ECO #4 Install closed hoods for Paper Machine #1 and Paper Machine #2

The existing hoods are open, allowing heat to escape. Installing closed hoods with a heat recovery system will minimize process heat loss. The heat recovered will reduce steam use by the paper machines.

ECO #5 Install a pith-fired boiler and matching turbo alternator

The mill's total requirement of 2.6 megawatts of electrical power is drawn from the State grid. Burning pith to generate electricity offers an opportunity to recover energy. Pith is a by-product of bagasse after fiber is removed to make paper. It is common for paper manufacturing facilities to install boilers which produce steam by burning pith. The steam can then be used to generate electricity.

The present plant capability comprises three boilers with a total installed capacity of 30 tph. Coal is the main fuel, along with a portion of pith. Because of the size and type of the existing boilers, all of the available pith cannot be utilized for burning.

Installation of a new high-pressure boiler, capable of burning pith as well as inferior coal, would allow the ability to generate high-pressure steam for producing electricity. In addition, a matching five-megawatt turbo alternator will convert the steam into electricity. With these pieces of equipment, the facility can reduce energy costs by generating electricity from a waste product.

ECO #6 Install capacitor bank to reduce maximum demand charges

Presently the mill has an overall power factor of 0.85. By improving the plant power factor to 0.95, the total kVA (maximum demand) of the plant will be reduced. This can be accomplished through the use of corrective capacitors. This measure will reduce electrical line losses on the utilities' distribution system and will reduce electricity costs for the mill.

ECO #7 Repair and replace thermal insulation

The thermal insulation in a portion of the plant's steam piping, tanks, and vessels is damaged or missing. By simple replacement of this insulation, steam loss will be reduced.

ECO #8 Replace old generation pumps by energy-efficient pumps

The survey team observed that the mill employs a considerable amount of old generation pumps. This was seen particularly in the areas of water intake and circulation. These pumps have efficiencies which are low compared to current standards. A detailed study of the plant can provide a complete list of low-efficiency pumps. Given the amount of electricity that pumping consumes, a pump replacement program is recommended.

ECO #9 Lighting improvements

Existing exterior lighting is mercury vapor technology. Replacing the mercury vapor lamps and ballasts with high-pressure sodium or metal-halide technology will significantly reduce the electricity cost of exterior lighting. Metal halide has a white light and is twice as efficient as mercury vapor. High-pressure sodium lamps have a yellow-gold light and are about three times as efficient as mercury vapor lights.

ECO #10 Better utilization of back water by closing the system

Presently, the water used in the paper-making machines is discharged. To reduce pumping electricity, the survey team recommends closing the water supply loop by recycling this process water, reusing it in the paper-making machines.

5.5 General Plant Data

Name of the Paper Mill	SHREE VINDHYA PAPER MILLS LTD.
Address of Registered Office	Somaninagar, Duskheda Bhusaval 425 203 Dist. Jalgaon (Maharashtra)
Location of the Factory	About 12 miles from Bhusaval City
Address of the Factory	Same as Registered Office
Phone Telex Telefax	(91) (02582) 2989/2759/2848/2879 -- (91) (02582) 2619
Date of Incorporation	29-07-1964
Name of the Mill Manager	Mr. P K Chopra
Name of the Proposed Coordinator for Energy Conservation Study	1-Mr. V P Chaudari, Sr. Utility Engineer 2-Mr. R C Maheshwari, Sr. Electrical Engineer
No. of Employees:	
Direct	776
Indirect	400

6. Orient Paper Mills Limited, Amlai Unit

6.1 Executive Summary

The Orient Paper Mill is located at Amlai in Shahdol District of Madhya Pradesh. It was incorporated in 1936. Presently, the mill manufacturers an average of 215 tpd of printing and writing papers, in addition to manufacturing pulp board and cover paper varieties at an average of 10 tpd. Raw materials include 65% bamboo pulp and 35% mixed wood pulp. The present number of mill employees is 2,711. During 1993-94, the mill had sales of Rs. 1,235.1 million ($39,842,000).

Though the mill is only 5 to 30 km from its coal suppliers, the plant is unable to get high-quality coal. While the plant is designed for C-grade coal, the coal they receive is inferior to this. It contains about 30 - 40% ash, in addition to having low calorific value. This poor-quality coal adversely affects the boiler and its steam-generation efficiency.

The mill has its own power generation capacity and can meet its operating power requirements. When their internal generation equipment is not working, power is purchased at a high price from the Madhya Pradesh Electricity Board.

The plant=s primary energy sources are steam and electricity. For each metric ton of paper produced, the plant uses an average of 15.2 mTons of steam, and 1,635 kWh of electricity. The largest share of steam and electricity is used in the paper making machinery. The objective of this report is to present recommendations to reduce energy consumption per unit of output.

Together, the survey team and plant staff identified the following Energy Conservation Opportunities (ECOs):

1. Replace the existing pneumatic chips handling system from the chipper to the digester by a suitable belt system

2. Replace the existing centrifugal screens with high-consistency pressure screens

3. Replace existing high-pressure-drop centricleaners with low-pressure-drop centricleaners

4. Replace existing evaporators with falling-film evaporators

5. Replace existing Jordan refiners with double-disc refiners

6. Retrofit existing spreader stoker-fired boilers to fluidized-bed combustion boilers

7. Install oxygen analyzer for the existing power boiler exhaust stacks

8. Install capacitor bank at the river-bed, intake well motor

9. Replace steam turbine with AC variable speed drive (VSD) for paper machine

10. Repair or replace thermal insulation

11. Upgrade existing lighting sources

12. Utilize backwater better by creating a closed system

If all of the above measures are implemented, the impact on the plant is estimated to be an annual savings of 119,000 mTons of steam, 15.14 million kWh of electricity, and 20,000 mTons of coal. The annual value of these savings is Rs. 82,380,000 ($2,657,000). The investment needed to realize these savings is estimated at Rs. 310,330,000 ($10,011,000), which would provide a payback of 3.8 years. These estimates are provided to determine savings potential. Sections 6.3 and 6.4 describe each of the ECOs. Detailed implementation designs will provide more precise estimates.

6.2 Process Survey Background

The mill utilizes bamboo and eucalyptus wood as the major raw materials for making several varieties of paper. The mill consumes around 110,000 mTons of bamboo and around 70,000 mTons of eucalyptus wood each year. The raw material requirement of the mill is obtained mostly from forest areas of Madhya Pradesh, Assam, Maharashtra, and Uttar Pradesh.

The two largest sources of energy consumption in paper making are in the paper machines, and in the pulping process. For this reason, many of the ECOs identified involve these process areas.

As *Table 6.1* shows, this plant consumes 15.2 mTons of steam per mTon of paper produced. The total electricity consumed is 1,635 kWh per mTon of paper produced.

Table 6.1 Process Power Consumption at Orient Paper

Plant/Machine	Fuel Consumed per mTon of Product		
	Steam (mTon)	**Electricity (kWh)**	**Water (m^3)**
Orient Paper Mills Ltd.			
Paper Machine	2.8 - 3.0	628	--
Pulp Mill	3.1 - 3.3	367	--
Overall Utilities Consumption	15.2	1,635	275 - 300

Steam and power consumption at this mill is higher than expected. Together, the plant staff and the survey team identified a list of energy-saving recommendations that can reduce energy consumption per unit of output. Sections 6.3 and 6.4 of this report present brief descriptions of these energy-saving opportunities.

6.3 Estimated Savings from Implementation of ECOs

Pulping Section

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #1 Replacement of pneumatic chips conveying system with belt conveyors	6.00	0.75	--	--	1.87
ECO #2 Replacement of existing centrifugal screen by high-consistency pressure screens	7.00	0.82	--	--	2.04
ECO #3 Replacement of existing high-pressure drop centricleaners with low-pressure drop centricleaners	3.50	0.35	--	--	0.87

Chemical Recovery Section

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #4 Replacement of existing evaporators with falling-film evaporators	130.00	--	110,314	--	22.06

Paper Machine

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #5 Replacement of Jordan refiners by double-disc refiners	90.00	7.22	--	--	18.04

Utilities

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO # 6 Retrofitting of existing spreader stoker-fired boilers to to fluidized combustion	34.00	--	20,000 (coal)	--	20.00
ECO #7 Installation of oxygen analyzers for the existing power boilers	0.90 (coal)	--	2,500	--	

Electrical

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #8 Installation of capacitor bank at river bed	0.13	0.03	--	--	0.08
ECO #9 Replacing steam turbine with AC variable drive for paper machine	29.70	3.42	--	--	8.55

General

Description	Estimated Investment (Million Rupees)	......Anticipated Savings/Year...... Elect. Energy (Million KWh)	Steam (tpa)	Water (Million m^3)	Anticipated Annual Savings (Million Rupees)
ECO #10 Repair and replacement thermal insulation	4.40	--	6,435	--	1.30
ECO #11 Lighting	2.20	0.25	--	--	0.63
ECO #12 Better utilization of back water by closing the system	2.50	2.30	--	1.19	6.94

TOTALS	310.33	15.14	119,250 + 20,000 (coal)	1.19	82.38

6.4 Recommendations

ECO #1 Replace existing pneumatic chips handling system (from the chipper to the digester) with a suitable belt conveyor system

The total connected electrical load in the chipper section is 3,304 kW. One area to conserve energy is in the systems which move the chips from one location to another. Moving materials by high- velocity air (pneumatic conveying) is more energy-intensive than performing this task with a belt conveyor. The mill implemented this energy conservation scheme by replacing most of the pneumatic blowers with belt conveyors. However, the chips conveying system from the silo to the digesters has not been converted yet. By converting the existing pneumatic conveyor to a mechanical-belt conveyor, the plant will reduce its electrical load.

ECO #2 Replace existing centrifugal screen with high-consistency pressure screens

The pulping section has centrifugal screens for screening unbleached pulp. The design of the centrifugal screens necessitates operation at a pulp consistency of about 0.5 to 0.6%. By implementing a higher-consistency pressure screen, energy will be saved by pumping less volume to achieve the same result.

ECO #3 Replace existing high-pressure-drop centricleaners with low-pressure-drop centricleaners

The pulp system uses centricleaners for cleaning unbleached pulp. The existing equipment creates a high pressure drop, and requires a low concentration of pulp in the slurry. It is recommended to change these units to more advanced equipment which will complete the same task with a lower pressure drop and allow a greater concentration of pulp. The result is reduced pumping energy.

ECO #4 Replace existing evaporators with falling-film evaporators

Presently, the mill has installed one street of long-tube vertical evaporators having a water evaporation capacity of 117 tph. An overall steam economy of 3.5-3.6 is achieved in the existing evaporation section. By installing an upgraded street of falling-film evaporators, which are rated at a steam economy of about 5.5, the mill will reduce its steam consumption.

ECO #5 Replace existing Jordan refiners with double-disc refiners

Presently, a dedicated, continuous stock-preparation-and-refiner system is installed with a total connected power load of 6,584 kW. This system includes two double-disk refiners and nine Jordan refiners. The Jordan refiners consume comparatively more electric power for the same throughput. By retrofitting the existing Jordan refiners with double-disk refiners, significant electrical energy will be saved.

ECO #6 Retrofitting of existing spreader stoker-fired boilers to fluidized-bed combustion

The mill's boiler section utilizes two coal-fired boilers, each with capacity of 91 tph working at 60 kg/cm^2(g) pressure. These boilers adopt a spreader stoker traveling-grate system. The boilers are designed for a coal grade at a GCV 5000 kcal/kg, whereas the coal being burned is of Grade `D' and `E' at a GCV of 4600 kcal/kg.

The mill normally runs two boilers with a total steam generation of around 3,061 mTons per day (tpd). The boilers thermal efficiency for the present fuel is:

Boiler #1	73%
Boiler #2	73%

The mill self-generates electricity. Its self-generation of 12.8 megawatts is close to the mill's requirement of around 13.1 megawatts. Presently, the balance requirement of around 0.3 megawatts is drawn from the State electricity grid.

The mill is also installing a Circulating Fluidized-Bed Combustion (CFBC) boiler of 100-tph capacity and 60 kg/cm^2 pressure, so as to have spare capacity in the steam generation system. This boiler is expected to be commissioned by April 1995.

By replacing the existing spreader stoker boilers with fluidized-bed combustion boilers designed for the type of coal available, the existing 73% combustion efficiency can be increased to 81%. This efficiency increase will reduce the amount of coal burned.

ECO #7 Installation of oxygen analyzers for the existing power boilers

When any fuel is burned, oxygen is required to support the combustion process. The oxygen is obtained from air which is fed into the boiler. If too much air is put into the boiler, the efficiency of energy transferred from the fuel into making steam is reduced.

To fully obtain the fuel's energy value, the mill should install an on-line oxygen analyzer of proven make for both spreader stoker boilers. The readout will guide the operator to optimize the excess air content in the boiler. It will also be beneficial to install a carbon monoxide sensor in the flue stack. Together, these instruments will assist the operators to maximize the boilers' fuel utilization.

ECO #8 Install capacitor bank at the river bed intake well

Electrical distribution losses are dependent upon the resistance of an electrical cable as well as the amount of current flowing through the cable. By installing capacitors on a motor, the amount of electrical current supplied to the motor is reduced which, in turn, reduces the amount of electricity lost by distributing it to the motor. When electricity is distributed over long distances, the economics of installing capacitors to reduce line losses become favorable.

The mill's water intake pump is located far from the mill. The electricity energizing the pump comes from the mill. Installing capacitors near the pump motor will save electricity by reducing electrical distribution losses.

ECO #9 Replace paper machine steam turbine with a VSD

For small drives, steam turbines have a large percentage loss in distribution of steam. The survey team recommends replacement of the existing paper machine steam drive with electric motors and VSDs. The steam saved will generate more electricity than the motor/VSD will consume.

ECO#10 Repair and replace thermal insulation

The thermal insulation in a portion of the plant's steam piping, tanks, and vessels is damaged or missing. By simple replacement of this insulation, steam loss will be reduced.

ECO #11 Lighting improvement

Existing exterior lighting is mercury vapor technology. Replacing the mercury vapor lamps and ballasts with high-pressure sodium or metal-halide technology will significantly reduce the electricity cost of exterior lighting. Metal halide has a white light and is twice as efficient as mercury vapor. High-pressure sodium lamps have a yellow-gold light and are about three times as efficient as mercury vapor lights.

ECO #12 Better utilization of back water by closing system

Presently, the water used in the paper-making machines is discharged. To reduce pumping electricity, the survey team recommends closing the water supply loop by recycling this process water, reusing it in the paper-making machines.

6.5 General Plant Data

Name of the Paper Mill	ORIENT PAPER MILLS (Prop: Orient Paper & Industries Ltd.)
Address of Registered Office	PO Brajrajnagar 768 216 Dist. Jharsuguda (Orissa)
Location of the Factory	Amlai, Dist. Shahdol (M.P.)
Address of the Factory	PO Amlai Paper Mills 484 117 Dist. Shahdol (M.P.)
Phone Telex Telefax	(91) (06645) 42376/42378 -- (91) (06645) 42338
Date of Incorporation	25-07-1936
Name of the Mill Manager	Mr. D. P. Saboo, Executive Vice President
Name of the Proposed Coordinator for (Technical) Energy Conservation Study	Mr. N. R. Agarwal, Vice President
No. of Employees:	
Direct	572
Indirect	2,139